Community Inventor Days: Scaffolding Grassroots Innovation with Maker Events

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ABSTRACT
This paper describes a series of *Inventor Days* designed to catalyse sustainable relationships between communities and makers to support grassroots innovation. By appropriating core properties of hackathons, the Inventor Days brought together residents in a community and makers from across the city. Over three events, makers and community members worked together to learn about the local area, design novel ideas that addressed local issues and build prototypes. We show evidence that these events created enthusiasm around use of technology to support the community, while developing ongoing relationships that enabled members of the community to continue building on their experiences beyond the events. We propose this as a new means of enabling innovation in communities.

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Community; innovation; civic technology; hackathon; co-design; participatory design.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

INTRODUCTION
Researchers exploring the use of technology in communities have long done so through deployments of prototypes in-situ, working closely with the communities themselves in various configurations of participatory design. Projects in communities like Blacksburg [7], Wray [27] and Tenison Road [25] have aimed to build meaningful relationships between researchers and communities, often over extended periods of time. Such projects can yield rich research insights about the use of technology in-situ, but they are also capable of having positive impacts on the communities by helping them to make the most of new technologies. This has been increasingly clear in recent years, as a "turn to the civic" [14] has seen projects with overt goals of empowering citizens to make positive changes in their environment.

However, major challenges have been identified in making these types of intervention sustainable [2, 27]. Interventions made during research projects, particularly those based on novel technologies, are often dependent on support and funding from the researchers, which will typically disappear when a project ends. Moreover, most communities do not have the opportunity to work with researchers in the first place. Instead, our research aims to understand how communities can be empowered to identify and respond to issues in their local area themselves, rather than simply acting as recipients of civic technologies.

This takes place against the backdrop of a growing maker culture that prizes skill sharing and open innovation, supported by open hardware platforms that aim to make it easier for amateurs to create their own digital products. However, rather than attempting to upskill everybody to the same level in utilising these technologies, we recognise instead that communities are made of people with diverse skills, goals and relationships. We propose that one way to empower communities is drawing on and developing these skills and relationships by bringing people together to work collaboratively around local concerns.

As a first step towards this goal, we were drawn to hackathons due to their capacity to bring different people together around a shared objective. While hackathons typically do not yield concrete solutions to problems, they might be effective in bringing together community members with makers and creatives. We intended that by bringing together those with technical skills and those with knowledge of how they might be applied in their community, we might be able to catalyse sustainable relationships that would outlast any research intervention. As a secondary objective, we expected that such events might generate insights and ideas that could be valuable to researchers and designers working on civic technologies.

In this paper, we describe *Inventor Days*, a series of hackathon-inspired events held in Ardler, a community in Dundee. These events brought together community members and local makers to imagine possible ways for technology to support their community, focusing in particular on the trend of physical civic technologies in public spaces [e.g. 11, 26, 30, 31]. We show how these events not only generated insights, ideas and prototypes for

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community technologies, but also created relationships, skills and enthusiasm that have already spawned further activity. Based on these findings, we contribute a new model for scaffolding relationships around community innovation, focusing on unlocking existing potential in the community, creating new skills and relationships and sustaining this energy in the longer term.

BACKGROUND

Our work sits against an existing body of work around civic technologies, grassroots innovation and maker culture. As we describe below, existing research highlights the challenges of empowering communities to address local issues, but also presents opportunities we can draw upon.

Approaches to Civic Technology

Much of the existing work around civic technologies in HCI has taken a somewhat top-down approach of deploying interventions into cities and communities. Although some of this work has involved working closely with communities [e.g. 14], few if any have truly been designed by the people who know their community best. The potential in this area is articulated by Townsend [29], who describes "civic laboratories" in which citizens are empowered to create their own solutions, some of which will be replicable elsewhere and others which will respond to unique local challenges. One approach to this has been "commissioning" platforms that allow existing applications to be quickly tailored to new problems [10], driven by the needs of communities. For example, App Movement [10] supports communities in customising a crowdsourced mapping app (for example, showing allergy awareness at different restaurants). This approach is effective in addressing problems that are well-defined and relatively common, but problems that are less understood require ways of identifying new solutions.

An alternative approach sees researchers acting in the role of 'friendly outsiders' common in action research [12]. In this role, researchers support communities in innovating for themselves rather than acting as drivers for innovation. One recent example of this approach being used for civic technologies is the Bristol Approach [4], a project that mobilised citizens across the city around the issue of dampness in homes, leading to the development of a sensor kit and a 'city commons' of data and knowledge. Projects such as Malmö Living Labs [5] have demonstrated the value of these approaches over many years for social innovation. However, such approaches are reliant on being able to effectively harness skills and relationships in the community—what Björgvinsson et al. [5] describe as "infrastructuring" to allow innovation to emerge.

Maker Culture

These grassroots approaches to civic innovation have much in common with maker culture, which has become a major focus for HCI research in recent years. Characterised by a broad mix of making skills from software hacking and traditional crafts, the movement is driven by an ethos of openness and skill sharing rather than commercial benefit, supported by digital fabrication and open hardware platforms. Often, makers are engaged in activities that take overtly critical approaches to matters of concern, including everything from community gardens to robots [20].

Although HCI has espoused the potential of making to democratise technology and empower individuals, there has been less consideration of the broader factors that might prevent this vision from being realised [22]. For example, Chris Anderson [1] demonstrates how digital fabrication empowers people to bring new products to market easily, but this is as much to do with his social capital as his access to technology. For most people, simply having access to this equipment is not empowering. Like action research approaches to civic technology, it is necessary to think not just about how communities might access equipment, but also how they might access knowledge and relationships—the infrastructure—that will enable them to come together and instigate change.

Making Events and Hackathons

It is for this reason that we turn to collaborative making events as a means of simultaneously providing access to equipment and knowledge while also nurturing these relationships and social capital. Workshop approaches have been taken in many existing projects, for example in constructing DIY sensor kits [16] and Internet of Things devices [18]. In this latter case, face-to-face workshop approaches were found to be particularly successful in maintaining engagement of non-experts: where someone might normally become frustrated and give up, the presence of experts at a workshop means they can provide timely advice and encouragement.

The most notable example of collaborative making events are hackathons: intensive sprints, traditionally around the development of code. Although hackathons have been mostly associated with software developers, with associated difficulties around inclusion [9, 21], there has been a recent shift towards more diverse mediums and audiences. This has included an increasing number of "hackathons with no hacking" [24] that focus more explicitly on the generation of ideas and the "performance of innovation" [24]. In this vein, hackathons have been documented working in areas as varied as music, fashion and dance [6]. There has likewise been a shift towards issue-oriented hackathons [17] that resemble participatory innovation while focusing on largely civic issues, while other events have foregrounded "idea exploration and playful tinkering" [28].

Amongst their varied forms, we find common traits of hackathons that are especially desirable. They are effective at bringing together different groups around a shared effort, who might not otherwise encounter each other [15, 23]. They also value *doing* over talking, turning attendees "from spectators of action to practitioners of action" [13]. Finally, they support informal peer learning [19]. Events that capture these key properties might be effective as a means

of infrastructuring community innovation by mobilising community members and makers around matters of concern.

PROJECT OVERVIEW

Our project aims to explore how community making events bringing together local people with makers might be used to create relationships and support innovation in communities. To explore this, we have worked closely with a single community across a series of *Inventor Day* events. Through these events, we stepped attendees through various stages of a design process and exposed them to technologies and platforms that could be used to make them a reality. Below, we give an overview of the project, after which we present each of the three events and the experiences of attendees.

Ardler

Ardler is a community in Dundee, Scotland, located on the northern edge of the city, outside the ring road that encapsulates much of the city. The community was constructed in the 1960s and originally comprised of six large high-rise tower blocks as well as smaller blocks of flats and individual homes. Like many such housing developments of this period in the UK, it went on to suffer a period of decline and social issues, until the tower blocks were demolished in the 1990s and replaced with a smaller number of modern homes and substantial green space.

Today, Ardler remains a community with some social and economic issues. Efforts at regeneration continue beyond the replacement of the housing itself, with long-term plans in place to foster social inclusion and community development. A key part of this strategy is the establishment of Ardler Village Trust, a partnership between various local bodies, who saw our project as a potential part of their digital literacy efforts.

Ardler Inventor Days

The Ardler Inventor Days were a series of three events, during which we aimed to work with community members and makers towards building community technologies. We chose to focus on the design of physical computing prototypes for the community, partly because our own research interests lie in this area, but also because the types of accessible platforms and technologies available to us—for example, Arduinos, Raspberry Pi, laser cutting—lend themselves well to physical computing, as do the non-digital making skills that might exist in the community. Each of the events built on the outputs of the last, moving from insight gathering and ideation, to experimentation with electronics and low fidelity prototyping, through to digital fabrication to develop a prototype that gave at least some indication of what a final product might be.

The Inventor Days themselves took place across three Saturdays, with three weeks between each six-hour event. This was intended to support wider participation, as we anticipated most community members would struggle to commit to longer blocks of time. We also welcomed children to the event, recognising that many of our target participants were parents with childcare obligations. Efforts to make the events as inclusive as possible extended to our choice of the term *Inventor Day* rather than less familiar terminology around hacking. Similarly, we located the first two events in Ardler's community centre to maximise the community's ability to participate. For the third event, we needed access to more fabrication equipment, so we located the event at the makerspace in the city centre. Transport was provided for those who needed it and we made attempts to build anticipation for this as an exciting finale.

Recruitment and Data Collection

With the support of Ardler Village Trust, we recruited at a variety of community events where we demonstrated examples of some of the technologies they might be able to work with across the Inventor Days, including 3D printing and simple electronics using conductive thread. From a mailing list of approximately 25 interested community members, a total of nine individuals attended at least one entire day each, with five of them attending all three events, including two children. Although this was fewer community members than we had hoped for, those who did attend were highly engaged and motivated.

We had anticipated that recruiting from the city's active maker and design communities would be relatively easy, but uptake proved to be quite low. Instead, we recruited a mix of local and non-local makers and researchers: the community manager of the local makerspace; an academic from outside our field who was a member of the makerspace; a makerspace manager and an electronics enthusiast from other cities; and three researchers from our group who were not otherwise involved in the project. This led to approximately a dozen attendees at each event, with a roughly even split between local residents and makers.

The findings in this paper are based on our observations of the events, supported by interview data collected afterwards. Most attendees were interviewed separately about their experiences, particularly how it lived up to their expectations and their expectations for the next event, as well as the aspects of the day that they found rewarding or frustrating. The researchers and several of the makers also held a debriefing session immediately after the event to reflect on their own experiences, particularly successful and unsuccessful aspects of the event's design.

INVENTOR DAY 1: GETTING TO KNOW ARDLER

The objective of the first Inventor Day was largely to establish a relationship with community members and makers, learn about the community, and develop an initial set of ideas that could be taken forward into subsequent workshops. Notably, this first event was not oriented towards building anything, but each part of the day was designed to keep participants actively rather than passively involved. This meant keeping the introduction to a minimum by simply stating what we intended to achieve over the course of the events and stressing the importance

the local attendees' knowledge of the community over the knowledge of technology. We also illustrated examples of civic technology using existing research prototypes [e.g. 26, 31]. This was followed by a short icebreaker and demos from the makers, who showed a variety of broadly physical projects to demonstrate the breadth of possibilities in this space and their achievability.

Walking and Talking

The first major task of the event was to walk the community. This took the form of ad hoc guided tours, where the local attendees led small groups on walks around the local area. Each group was given a map and a little time to plan a route around the neighbourhood that would take in things that they felt were significant points of interest or that they might be interested in exploring through the Inventor Days. This was intentionally a sharp contrast to events that are normally confined to one space.

One group focused extensively on the history of the community and the multi-story towers that had existed there before the redevelopment. Steve, the leader of the group, regularly opened old photos of the area on his phone to compare the original buildings to the new estate. He discussed the loss of shops in the local area, the changes to the community that were brought by the redevelopments, rivalries between different areas of the community and a wooden play fort that had previously stood on an empty playing field. A larger group explored the area around the two local primary schools before splitting in two. One group remained around the schools, discussing problems with road safety and gardening efforts, while the second explored nearby wooded areas and green space.

On returning, conversations that began during the walks continued over lunch as the groups came together. Although we had not planned this aspect of the day, the groups naturally converged to share their walks, with conversation quickly expanding into wide-ranging discussions about the community. It was during this period that many of the most distinctive insights about the community began to emerge: discussion ranged from local legends about crocodiles and dragons, to the underuse of greenspace and nearby woods in the local area, to the community's successful Santa's grotto and charity shop. Rhona, the makerspace community manager, described how this part of the day saw *"everybody getting around up by the table and sharing stories and swapping ideas* […] *they spoke to each other over the table and they listened to each other because they were nice and relaxed"*.

What was notable at this point was how the walks had already brought together the group of disparate community members and makers, most of whom did not know each other prior to the event. It also put the community in the position of being the experts rather than the makers coming in with technical expertise. The focus shifted away from technology and onto the community members' knowledge of their local area and helping makers to gain a sense of

Figure 1. Community member and makers visiting green space in Ardler.

what Ardler was like. This also removed pressure on the makers to be the creative influence (Anna: *"I really liked that all the ideas were not coming from my head. I liked that they were coming from people all around me"*).

Opportunities, Challenges and Ideas

In the final segment of the day, attendees were asked to frame their insights as either Opportunities (positive things that could be built upon) or Challenges (issues that might be addressed), writing these on pre-printed templates and pinning them up around the venue. After briefly presenting these to the group, they were asked to pick one or more opportunities or challenges (not necessarily their own) and work in groups to generate ideas. A range of craft materials (e.g. modelling clay, Lego and cardboard) was available for them to build representations of their ideas.

From this exercise, clear themes began to emerge that could be addressed through the subsequent Inventor Days:

- *Greenspace* involved devices spread through the woods that would mimic birdcalls, creating an educational trail to promote use of local greenspace.
- *Local legends* included ideas around mythical animals, particularly building a crocodile that allegedly lived in the pond visited during the walk.
- *Community events* responded to concerns that people did not know what was happening in the community and included a variety of ideas for digital noticeboards.
- *Redevelopment* focused on the former estate and ideas that captured the heritage of the community, like restoring the play fort.
- *Traffic Safety* overlapped with greenspace in proposing interactive trails to keep children away from roads.

Another notable observation at this point in the day was how groups who had attended together and clustered together at the beginning of the day were now split up and interspersed across different ideas. Even the two parents and their children were working independently, particularly Holly, whose mother Rebecca said was normally shy and

reserved, quickly struck up a friendship with one of the makers that would continue through the rest of the Inventor Days. But attendees also moved fluidly between groups, contributing to each other's models and ideas.

Makers noted marked differences between the event and their experiences with either makerspaces or hackathons. This included being more sociable (James: *"I don't want to go and sit in a corner and bash out a problem, I want the social side of it"*), engaging with less technically-oriented activities (Mike said that the makerspace was typically *"not oriented towards community goals"*) or broadening their horizons by engaging with different types of people (Rhona: *"you're really limiting yourself if you only do design work with your peers* [rather than] *people who can actually help you change your own practice"*).

However, not everybody was fully comfortable. Two older female attendees, who had been actively engaged in the walk and discussion lunch, appeared hesitant to share their ideas, highlighting challenges around people's comfort with creativity and public speaking. Although both left due to pre-existing commitments, we found that other attendees became more comfortable as we moved away from more formal presentations of ideas and toward modelling using craft materials.

After the Event

From interviews, it was clear that neither the community members nor the makers had been fully certain what to expect from the event. For some, they had anticipated more lectures about technology or step-by-step workshops, while makers had imagined there was an existing group in the community engaging in making. Despite this, all the attendees except for the two who left early intended to continue attending the rest of the series.

In the intervening three weeks, many of the attendees continued to think about their ideas and how they might be taken forward in subsequent events. Rebecca, a childminder from the community, had given thought to how various ideas overlapped around her interests and how these might be taken forward, intending to return to the specific idea she had been working on. She had been enthusiastic in talking to friends in the community, attempting to recruit others for the second event and telling people about the existence of the city's makerspace—which she had heard about through the event but not yet visited. Others took more proactive approaches: for example, Steve had ordered a Raspberry Pi and dismantled a plug-in air freshener to extract an infrared sensor based on a conversation with one of the makers. Mike, a member of the local makerspace, had done research in the meantime around ways of powering installations in the woods, assembling various components for a wind-up power source.

INVENTOR DAY 2: PLAYING WITH TECHNOLOGY

The second Inventor Day aimed to pick up ideas and themes from the first event and begin exploring how they could be made through playful experimentation with electronics. The event again took place at Ardler's community centre, which was decorated with materials generated during the first Inventor Day, including the challenge, opportunity and idea sheets. In addition to the craft materials provided at the first event, a large selection of electronics was provided and set out in the space. These included Arduino and Raspberry Pi boards with various expansions and toolkits, conductive inks and thread, plus a wide selection of components. These platforms were chosen due to their suitability for the kind of physical computing that we had focused on, as well as familiarity amongst the makers and accessibility for newcomers. At the beginning of the event, we briefly talked through what each of these pieces of equipment was capable of.

Building Teams and Developing Ideas

We encouraged attendees to spend time reading some of the materials on display from the previous event, before forming teams around an idea or theme. We were clear that people did not have to remain with the same teams, ideas or themes that they had developed last time. We also made clear that they were free to work on something else if they had different ideas that they wanted to develop. Although we had expected this to need careful facilitation, three teams formed quickly over a coffee break, with only a small amount of facilitation required.

The largest team coalesced around the *community events* theme, specifically around the idea of a community noticeboard or *Info Box*. This team included Steve, Mary (a community organiser) and Gareth (a staff member from the local charity shop), who worked with Paul, an experienced product designer who had not been at the previous event. This team was notable for the strength of enthusiasm around the idea, particularly because Mary and Gareth saw real purpose for such a device. In Mary's case, this was because she was responsible for organising and promoting events in the community, so a digital noticeboard was an additional tool she could utilise. For Gareth, his position in the shop meant people often asked him about upcoming events. This lived experience of the issue being tackled also manifested itself in very practical discussions about how content might be generated or updated, giving practical insight into realities of the community. Paul commented that normally *"you don't even touch on that stuff, because it's just technical production"*.

A second team, *Traffic Trails*, consisted of just Mike and Rebecca working together throughout the day. Their idea was a device that would keep children who ran ahead of their parents away from the roadside, using some form of game or musical interface. This built directly on the ideas Rebecca had developed during the first event, as well as several other ideas in the *road safety* theme. Given the level of discussion around traffic problems and many variations on the basic idea of a roadside trail, Rebecca had expected more people to be interested and described pushing forward

the idea on her own as intimidating: *"it was kind of just me, which I found quite daunting* […] *so it was really, really good that I had* [Mike] *to show me what to do* […] *because in the beginning I was like, this is crazy, I can't do this"*.

Finally, a third team, comprising two makers and Rebecca's daughter Holly, worked on the *Local Legends* idea that had emerged from the first event. This resulted in the construction of a large, wearable dinosaur head, constructed from foam and cardboard with illuminated eyes that were activated by motion (seen to the left of Figure 2). Although this team drifted away from community technologies, the idea remained grounded in insights from the previous workshop, while the impressiveness of the model and Holly's enthusiasm became focal points for the day.

Making Together

Of the three events, the second Inventor Day gave the greatest indication of how community members and makers could work together, demonstrating a variety of different configurations amongst the teams. Even within groups, different dynamics emerged that varied between education, collaboration and client relationships.

This variety was most evident in the Info Box group, where a single maker worked with a group of three community members. Their final prototype included a scrolling LED display with a button to change the message shown, as well as a multi-coloured grid of lights intended to attract attention when new messages were available, all of which necessitated much more coding than the other groups. For Steve, this presented an opportunity to engage with electronics and coding: *"I didn't expect it to be as hands-on as what it was. I've never been interested in computing or building things, or doing anything like that. Until that day, until the Saturday, when I got my hands on the Arduino boards"*. For him, part of the value of attending was learning what was possible and how much (or little) effort it required. Steven and Paul formed something resembling a pair programming team, including one memorable moment when both realised they had been programming the wrong Arduino board (captured in Figure 2).

Conversely, Mary displayed little interest in becoming involved in the making herself, preferring instead to direct the idea and allow others to take charge of delivering it. However, as discussed above, she brought other specific knowledge and experience that grounded the idea in the realities of the community. Paul, on the other hand, brought design sensibilities in addition to technical expertise, by pushing the group to explore what a digital solution might bring that a traditional noticeboard did not.

Rebecca and Mike's pairing functioned very differently: Mike had previously discussed the importance of acting in an education role rather than simply doing things for people, a value shared with his makerspace. He coached Rebecca through coding the Arduino to control LEDs and tactile arcade machine buttons, working from a tutorial

Figure 2. Activity during the second Inventor Day.

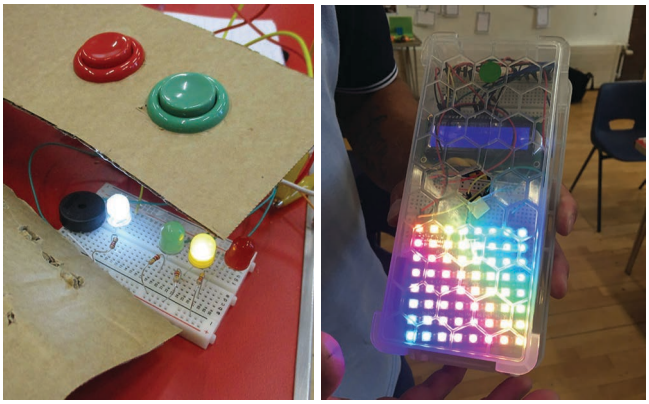

Figure 3. Low fidelity prototypes for Traffic Trails (left) and Info Box (right).

book included in the Arduino kit. She spent most of the day working on this task, even recreating the code from scratch after a technical issue led to it being lost.

For the research team, seeing Rebecca develop an understanding of code from no prior knowledge was a remarkable outcome. However, in follow-up interviews she expressed regret at having spent the entire day coding, having expected instead to be *"more in the designer* [or] *creative side"* and would have rather experimented with conductive ink that spoke more to her craft sensibilities. This highlighted very different objectives between Rebecca and Mike: while she wanted to push the project as far as possible in the time we had, he thought it was more important to build a solid foundation of knowledge on which Rebecca could later build herself. But despite finding the day mentally exhausting, it remained a positive experience for her. As a mother and childminder, most of her creative activities involved children, but the Inventor Days allowed her to *"tap into* [her] *creativity again in a more adult way"*. Part of what enabled this was her daughter being engaged separately with other makers.

Across all the teams, there was a strong sense of relationships building between the participants, which had been maintained since the first Inventor Day. Rhona, one of the makers, described how they now felt like *"peers rather than your alien force sort of introduced into it"*. Unlike more competitive hackathons, teams were relatively fluid and cross-pollinated. Mike tinkered with electronics when

Rebecca was engaged in coding, while another maker worked alone to set up a Raspberry Pi, thinking it would be useful in the future. Furthermore, many of the community members and makers alike described their sense of achievement with prototypes that, although low-fidelity, had come into fruition within a very short timeframe.

After the Event

As with the previous event, Steve and his son had remained particularly engaged afterwards. He had discussed his team's Info Box idea with a variety of people, including generating interest from a local shop and thinking about using a Braille printer to make it accessible. They had also ordered Arduino kits online, scouted out the makerspace and developed a range of ideas for things they could build together—some of which they had already begun to work on. This included scavenging and experimenting with a light sensor to develop an idea for a car window display that would only illuminate at night. Of all the attendees, Steve seemed to have become particularly enthused by the possibilities of programming and electronics, including as an activity that allowed him to spend time with his son (*"he'd normally go and play with his pals and I would probably just sit in the garden* […] *the Inventor Days have given us a new thing"*). Mike, one of the makers, had also worked on slot-together laser-cut crocodiles that he intended to share with the Local Legends team.

However, it also became increasingly clear that expectations for the outcomes of the events were high amongst the community. Several community members talked about their desire to see prototypes finished and out in the community, particularly given the level of effort and personal investment that had been put into them. Mary, the community organiser, was particularly keen to see this happen: *"I think if there was nothing going out it would be the* [attendees] *who would benefit I think more than the community. I think for the community to benefit there does have to be something at the end of the day"*. While this was our ultimate intention, it was unlikely that any of the ideas would reach this stage during the final event.

INVENTOR DAY 3: FABRICATION

The final Inventor Day was a sprint to push their existing ideas and low-fidelity prototypes as far as was possible in the remaining time. This took place at the makerspace near the city centre, as we wished to provide access to laser cutters and to introduce community members to the space itself as somewhere they could access equipment and knowledge in the future.

Revisiting Ideas

For each of the teams, the main challenge at this final event was in recovering momentum after a three-week break and identifying how they could best push their idea towards something resembling a finished prototype in the time remaining. For some teams, there was a clear idea of how their idea should progress and the final Inventor Day was very much about progressing as far towards this goal as possible. For others, the final event was an opportunity to step back and try a different approach.

Of all the groups, the Info Box team had the clearest idea of what they wanted to build. Nevertheless, the team spent considerable time working at a flipchart to refine how people would interact with their prototype, including taking some advice on interaction design from the research team—the only time we saw this level of design work happening. This was partly due to changes in the team: Mary, who had a strong voice in the group at the previous event, could not attend, nor could Paul, the maker on the team. Instead, Sean, who had worked alone on a Raspberry Pi at the previous event, joined the team. This led them to switch from Arduino to Raspberry Pi, partly because of Sean's expertise, but also so that they could drive a more conventional LCD display rather than the scrolling text display that had been used previously. Between this switch and their design work, the project lost some of its more outlandish features—such as touch sensitive panels and multiple screens—settling on a slideshow that could be navigated using physical buttons.

Rebecca and Mike's Traffic Trails project was joined by Anna, a doctoral student with a design background, who had worked closely with Rebecca at the first event. This time, Rebecca was keen to embrace her creativity more given her experience of coding at the previous event (*"because I knew more what I wanted, I could say well this is what I want to do"*). For example, although she tried soldering for a little while under Mike's supervision, she quickly passed this over to him to complete. Instead, she and Anna worked on designing the physical form of the device. They paid much more attention to the physicality of the idea rather than the functionality, coming to see the prototype as a blank canvas, where the actual game running on the device would vary over time. This allowed minimal development, meaning Rebecca could focus on the more craft-based aspects that she enjoyed.

For the Local Legends team, it was not immediately clear what direction they could take their idea. Their dinosaur was already relatively well-resolved as a physical model by comparison to the other prototypes and their ambition to build a full-size outdoor model was difficult to realise further. Instead, the group worked on several smaller ideas mainly utilising the laser cutter, including making small light-up badges of crocodiles and dinosaurs. There was some discussion of how similar objects might be sold to raise money for charity, which ultimately brought the idea back to a community-oriented objective.

Exploring Digital Fabrication

The primary motivation for hosting the final Inventor Day at our local makerspace was to enable access to digital fabrication equipment. Although we had brought 3D printers to each of the previous events, they were only used for demos due to the amount of time required to model and print anything. We suspected that the makerspace's laser

Figure 4. Finished InfoBox prototype.

Figure 5. Part of the Traffic Trails prototype.

cutter would be more useful in creating housing for electronics, where the Info Box and Traffic Trails had previously used a scavenged plastic container and cardboard respectively. Both teams ultimately gravitated towards laser cut interlocking boxes (Figures 4 and 5). As with the electronics, we made a broad range of materials available, in addition to scrap materials freely available at the makerspace, which the Traffic Trails team made use of to create plastic creatures that adorned the front of their prototype, which the team and other participants were particularly pleased with.

For the makers, being at the makerspace was akin to being on home turf. Mike talked about how this meant *"there wasn't that question faffing about trying to find things or work out what it is or how you're going to do it"*. But this also put some of the makers in the position of acting as hosts: for example, towards the end of the day Rhona was working intensively on the laser cutter to ensure that everybody's prototypes were finished on time. This was clearly stressful for her and distracted from being able to work on her own group's project. For her—and for the event's goals—it would have been preferable for some of the community members to experience operating the equipment themselves. Despite this, hosting the event at the makerspace exposed members of the community to a resource that they would not otherwise make use of. For example, Rebecca was actively considering using the makerspace to continue her idea.

After the Event

The community that emerged around the Inventor Days—in which we include ourselves—has continued after the events concluded. We invited all the participants to visit our studio to share with them some of the work we had been developing based on the outcomes of the events and later hosted a showcase in the community to share their inventions with other Ardler residents. With the research team, Steve gave a short presentation on his experiences in front of an audience of various makers and creative practitioners at an informal local event. What was striking about these events was the ongoing strength of the relationships between community members and makers and the wide variety of other activities that had been inspired by the events.

Steve and his son continued to contact makers outside the Inventor Days to ask for help and advice on electronics. For example, he and Mike had discussed making bird boxes and bat detectors with cameras and he had even contacted a technician from the university that he had met while visiting our studio. He had also built electronic Halloween decorations, drawing on work done at the event and communication with makers afterwards. His son had continued to develop his own ideas, such as a messaging system for his school, which was directly inspired by one of the demos he had seen when they were first recruited. Other attendees were likewise inspired by their new knowledge: Gareth had an idea for an interactive toy for his goddaughter, which he now felt was achievable.

Rebecca's ongoing activities were less technical but no less impressive. She had approached Holly's school about running an after-school club around making and science, which would involve undertaking a project over the duration of an entire academic term. This idea had recurred throughout our interviews with Rebecca, where she had initially talked about not having the confidence to run that kind of event on her own, but within a few months of the Inventor Days she had hosted a school assembly demonstrating science experiments and was seeking local funding for the club. While the focus of the club had diverged from the original idea of an electronics club, the Inventor Days had still acted as a catalyst for her ambitions.

DISCUSSION

Across three Inventor Days, we saw members of the community and makers coming together in various configurations to examine the community, imagine possible community technologies and build prototypes. To us, the main outcomes of these events were not the prototypes themselves, but the ongoing relationships and newly inspired community members actively undertaking

activities that linked back to the events. Below, we set out some of the ways in which the Inventor Days supported these outcomes and how they might be used to move further towards the goal of sustainable community innovation in the future.

Unlocking Potential

While the Inventor Days led to new ideas and new relationships in the community, what is most striking is what was already there. The events brought together a wealth of existing knowledge about the local area, enthusiasm for the community and its future development, and creativity. Ultimately, these are the resources that are most difficult to create and the ones that are most valuable in making a positive change. The Inventor Days proved capable of bringing these community resources together and focusing them towards a goal.

One of the most successful ways of achieving this was by *reframing making in the familiar*. People who are not intrinsically interested in making or electronics, or who feel it is outside their abilities, might still be interested in doing something positive and creative in their community. By framing the activity in these terms, we attracted attendees who would not normally attend such a technology-oriented event, but who made valuable contributions and went on to undertake further activities as a result. Furthermore, by placing the initial emphasis on the local area and activities like the walk, the events placed community members in the position of being the experts. This created roles in which they could contribute immediately, while technology was introduced slowly, giving community members the opportunity to learn along the way. Makers also responded well to this emphasis, which created what Mike characterised as a two-way knowledge exchange.

More practical factors also played an important role in reaching a diverse audience, such as situating earlier events within Ardler itself, welcoming children and spreading the time commitment across multiple short events rather than an intensive weekend. Attendees said that they would have been unlikely to have attended the first event had it been located at the city's makerspace, for example. These considerations all reduced barriers to participation that can otherwise easily discourage people and which have been a common criticism of the hackathon model. We anticipate that these practical lessons might be useful to others attempting to engage a wider audience in such events.

While we may have only been able to engage with a relatively small number of motivated community members, we have seen evidence of how this can be a starting point for wider activities. Whether this is Steve and his son continuing to share new inventions with family and friends, or Rebecca engaging with the school and other parents to drive forward new initiatives, the energy and spark of creativity that was unleashed at the Inventor Days has continued to be applied to the things people care about. One way to support this might be to further emphasise skills that exist in a community, such as more traditional craft skills. As we saw with Rebecca's experience, she was keen to bring her creativity to bear on local issues, but less excited by the prospect of coding and electronics. Drawing on this kind of enthusiasm could support wider engagement.

Innovation and Insights

A secondary goal of the Inventor Days was to develop original ideas for civic technologies, some of which might be unique to Ardler, while others might have potential to be replicated across other communities. However, the designs that emerged from the Inventor Days were not as rich as the other positive effects around the events. For example, despite the InfoBox being the most well-resolved idea to emerge from the events and one that had considerable enthusiasm behind it from the community, it was also a relatively common idea amongst community technologies.

There is a well-acknowledged tension between novelty and sustainability [3, 27], but in the context of communities innovating for themselves, we would argue that sustainability is much more important. Whether the idea is new or not does not affect its ability to make positive change, but the community's ability to identify their needs and how to address them might. However, the rich insights into the community that emerged through the Inventor Days might also be used as inspiration for other designs. These were both practical insights into challenges that might be faced by other similar communities (e.g. traffic), but also inspirational insights that were very specific to Ardler, such as the local legends or Santa's grotto.

What happened at the Inventor Days might therefore be seen more as a form of community research. Combined with the clear ambition of attendees for field trials of their ideas in the community, we believe these events could act as the beginnings of a civic laboratory: "innovative communities where people are eagerly adapting smart technology to unique local needs" [29]. Townsend's vision of smart cities being defined from the ground up perfectly encapsulates the spirit of coming together and thinking about technology that we attempted to create.

Learning and Mentoring

Our motivation for bringing together community members and makers was initially about connecting together the needs and knowledge of the community with the skills of the makers. Although we had not framed this as overtly educational, we found that in addition to harnessing the existing skills and knowledge, there was also considerable transfer of knowledge into the community. Not only did the community members gain much more hands-on experience and new knowledge than we had anticipated, but the makers also seemed to value working in this role: whether this was Mike fulfilling his role as an educator or Rhona developing her personal practice as a community facilitator.

This educational component aligns with recent efforts, particularly around schoolchildren, to develop more coding

ability in the public. Opportunities for adults to gain digital skills are most often concerned with developing skills that might be immediately useful in employment, but as Rebecca told us: *"people need to play"*. The community became interested in developing these skills when exposed to them in the right way, but to do so normally means learning alone from internet tutorials or accessing help at makerspaces, which can be intimidating for many. As Mellis et al. [18] found, face-to-face contact is extremely valuable in developing these skills amongst inexperienced makers. We certainly found that creating a fun and friendly environment in which to explore technology was beneficial.

We believe the Inventor Days showed great potential as a tool for developing digital skills in adults who would not normally seek them out. By bringing making to the community, making it playful and framing it around the local area where they could see potential value, we were able to engage with new audiences and transform enthusiasm for the community into enthusiasm around making. Other possible ways of framing this emerged, especially from parents who saw the events as opportunities to spend time with their children. In either case, finding ways to transfer skills into the community is an important way of supporting innovation in the longer term.

Scaling and Sustaining

We began this paper by motivating the need for communities to be able to innovate for themselves without the intervention of researchers such as ourselves. The potential for infrastructuring this grassroots innovation by building relationships amongst community members and makers is evidenced by the wide-ranging activities undertaken in the community beyond the Inventor Days themselves, often building on relationships and knowledge developed during the events. However, it remains the case that our intervention was required to bootstrap these relationships. While we consider ourselves to be part of the community that formed around the events and intend to maintain our engagement with Ardler, it remains important to reflect on our role and how this process might play out without us.

Our role in the events included recruiting both community members and makers, designing and organising the events themselves, and providing equipment and materials. We tried to influence the teams' projects as little as possible. By comparison, in past projects we have often spent up to several years engaging with communities and led most, if not all, technical aspects of the project [27]. Relative to this past work, the Inventor Days bootstrapped a community around the events with relative speed and few technical challenges. Considering our objectives, this difference is significant because it places the activities we have described within the realms of possibility for various community organisations and local authorities, not just for researchers.

This possibility leads us to imagine models like Code Clubs, a UK project that uses a relatively small number of highly-motivated volunteers to run coding lessons for children. A community-oriented making club, supported by local organisations, might be able to sustainably replicate the role that we played in this project. We believe there is also scope for community members who have already been engaged to act as champions, spreading the skills they have learned and engaging others in nearby communities. Rebecca's after-school club demonstrates the potential for propelling participants into this kind of role.

A remaining challenge is how to motivate those who might fulfil the role of mentors and bring making skills into communities. There may well be a place for universities and researchers in taking on this role, but local enthusiasts are likely more plentiful in many areas. Although the makers who attended all reported finding it rewarding, recruitment was much harder than we had anticipated, particularly given the city's vibrant and close-knit creative scene. Rhona, the makerspace community organiser, suspected that many of their members were over-burdened with events and hackathons. Makers clearly enjoyed the peer learning that emerged in exchanging knowledge about the community and technology, and several spoke about the importance of engaging with new audiences. But at the same time, we saw examples of makers falling into a service provision role, such as Rhona's use of the laser cutter. Replicating this model in other communities would require closer attention to the roles in which makers are cast and what benefits they can derive from the relationship.

SUMMARY

Supporting communities in innovating and making the best use of technology in their local area is a difficult challenge, combining a need to both develop technical skills and create social capital. Taking cues from hackathons but developing into something very different, our Inventor Days present a new model for creating the circumstances under which grassroots innovation might flourish. This is only one part of a broader challenge, but we believe that the core aspects of the Inventor Days—putting the community first, placing community members in the role of expert and playfully exploring technology together—could be reapplied in a wider range of circumstances to support more people in making positive contributions to their local area.

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DATA ACCESS STATEMENT

Anonymised data used in this paper is available upon request from the University of Dundee repository [8].

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